

The EPA is to be commended for anticipating that alternating use of herbicides on a crop can drive the evolution of multiple herbicide resistance in weeds. To that end EPA has created a stewardship plan that should - in general - act to the delay the evolution of such resistance under weed control with 2,4-D/Glyphosate. Unfortunately, the baseline situation already involves species resistant to one or the other herbicide family. Indeed, there are already populations of wild radish in the state of Western Australia that have evolved resistance to both 2,4-D and glyphosate. The same Australian populations have evolved resistance to two other herbicide families. Worldwide, 27 weed species have evolved resistance to glyphosate; 29 species have evolved resistance to 2,4-D. Of the 27 species that have evolved resistance to glyphosate, 13 have already evolved resistance to one or more other herbicide families. Of the 29 species that have evolved resistance to the 2,4-D family, 8 have already evolved resistance to one or more other herbicide families.

There are two species in the United States that are particularly worrisome with regards to the evolution of joint resistance.

(1) *Kochia scoparia* [a.k.a. kochia] has already evolved resistance to 2,4-D in five states (Montana, North Dakota, Nebraska, Idaho, and Colorado). The same species has evolved resistance to glyphosate in seven states – including four in which 2,4-D resistance has evolved (in different populations). The combination of selection pressure under herbicide use plus gene flow between populations would be expected to drive the evolution of joint resistance in kochia in those four states – Montana, North Dakota, Colorado, and Nebraska.

(2) *Amaranthus tuberculatus* [a.k.a. waterhemp] has already evolved resistance to 2,4-D in Nebraska and another Nebraska population of the same species has evolved resistance to glyphosate. The combination of selection pressure under herbicide use plus gene flow between populations would be expected to drive the evolution of joint resistance in waterhemp in that state.

See this website for the source of the foregoing data:
<http://www.weedscience.org/summary/home.aspx>

The management stewardship plan should work relatively well to delay evolution of resistance in species that have no history of resistance to either glyphosate or 2,4-D, but it is not clear how well it will work when resistance to one or both herbicides are already present with a species.

It is also worthwhile noting that the *Amaranthaceae* (to which both waterhemp and kochia belong) is a statistically significant taxonomic "hotspot" for the evolution of herbicide resistance. Likewise, annual weeds, such as waterhemp and kochia, evolve herbicide resistance many times more frequently than perennials. See
<http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0071916> and
<http://onlinelibrary.wiley.com/doi/10.1111/nph.12698/full>

I urge EPA to deeply consider whether its proposed management stewardship plan will be sufficient to prevent the rapid (on a scale of a few years) evolution of joint 2,4-D/glyphosate resistance in waterhemp and kochia.